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Handbook of Transdisciplinary Research

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Chapter 13

Policy Analysis and Design in Local Public Management: A System Dynamics Approach

Markus Schwanninger, Silvia Ulli-Beer and Ruth Kaufmann-Hayoz

Abstract The purpose of this article is to draw lessons for transdisciplinary modelling endeavours in social contexts. The chosen approach is to explore a research project that was part of the Swiss National Science Foundation's 'Swiss Priority Programme Environment' (SPPE). The project focused on ecological issues and was realised in collaboration with local actors from a Swiss municipality. The case study design is used to analyse methodological issues related to the study of complex dynamic challenges. For example, for the purpose of policy design and learning, pertinent examples of the roles of heuristic frameworks and of simulation models are examined. Another challenge is to involve problem owners in the inquiry process. Furthermore, the transdisciplinary approach, in order to gain a better understanding, is addressed. These issues will be illustrated by means of system dynamics modelling and analysis of current challenges in the realm of solid waste management. Finally, the chapter makes several recommendations to researchers who want to investigate multifaceted, dynamically complex issues together with practitioners.

Keywords: Policy design · Policy analysis · Recycling management · Model-based theory-building · System dynamics

13.1 Background

This chapter refers to a research project, which is presented as a case study. The project originated within the 'Swiss Priority Programme Environment' (SPPE) of the Swiss National Science Foundation (SNSF).

The work we are referring to is called '*Citizens' Choice and Public Policy*'. In this research project, the general issue of citizens' choice is related to the study of environment related behaviour of citizens and exemplified by a modelling and simulation study to identify effective public policies. The concrete study object chosen

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was the *management of solid waste at the local level*. The objective of the study was to explain the dynamic interaction between public policies and environmentally relevant behaviour of citizens, and to provide solutions for environmental management in communities.

In the following, we will elaborate on the research design of the project under study. A report of the different phases of the project with an overview of the heuristics and instruments used will ensue. Finally, several lessons for researchers will be drawn from the analysis of the project.

13.2 Research Design

In view of the purpose of the research project, the main questions to be answered were:

- What are the factors triggering citizens' environmentally relevant behaviour?
- How can actors be influenced towards an environmentally friendly behaviour pattern?

To answer these questions, the specific objective was to build and explore a simulation model, which should lead to better decision making.

Given the complexity of the issue under study, the basic orientation of the project had to be a *transdisciplinary* one. It was clear from the outset that the knowledge necessary to accomplish the project reached beyond one single field of study. The relevant knowledge had to come from different disciplines and included system experts, i.e. persons who were knowledgeable about the system under study. Also, several constituents had stakes in the inquiry, i.e. they were affected by or interested in the inquiry. Therefore, we needed more than a merely multidisciplinary procedure, by which a number of specialists would be consulted: we required mutual communication that would cross boundaries not only between different disciplines but also between science and practice.

Transdisciplinary processes of inquiry or design are characterised by one essential feature: they unite experts from different fields – usually disciplinary – to cooperate, the interaction being facilitated by a common framework or code enabling effective communication across different disciplines and perspectives. The common code is, in principle, a formal language provided by sciences such as system theory, cybernetics or mathematics. In our case, the *System Dynamics* methodology was the core device for integrating concepts from different disciplines in a simulation model and analysing the issues.

System Dynamics (SD) is essentially a system theory based methodology for the modelling and simulation of complex systems, which provides an effective platform for a transdisciplinary dialogue in policy design and learning. It is a widely used methodology developed by Prof. Jay Forrester at MIT-Massachusetts Institute of Technology (Forrester, 1961). SD models are made up of closed feedback loops

and the systems modelled are simulated as continuous processes; the mathematics of the models are based on differential equations and integration (Sierman, 2000; Barlas, 2006). SD is particularly useful for discerning a system's dynamic patterns of behaviour, which may be 'counterintuitive' (Forrester, 1971).

The research strategy chosen is one of *action science*. Argyris et al. (1985) define action science as a research approach that combines the study of practical problems with research that contributes to theory building and testing. The authors start from two premises. Firstly, it is necessary to understand the world in order to manage or transform it in a desired direction. Secondly, in order to understand the world, an attempt should be made to change it. Consequently, the protagonists of action science advocate issue- or problem orientation and favour the participation of exponents of different disciplines, and practitioners. Hence, this kind of research implies a transdisciplinary approach to strengthen the inquiry process.

Action science aims at improving social and human systems. Many applications have been documented, including cases where researchers and decision makers cooperated to address issues of organisational learning (Argyris and Schön, 1996). As this literature reveals, a crucial concern of action science is the development of strategies for sustainable change. Efforts to reveal defensive forces that try to maintain the status quo play an important role, as does understanding the consequences of actual and potential interventions, in the light of context dependent action of human beings.

The research project was composed of two parts:

Part I: A research methodology was developed, and a conceptualisation of the issues under study – environmentally relevant behaviour of citizens and effective public policies – was accomplished. The method followed in this part was essentially a study of literature and the deductive development of a heuristic framework.

Part II: The development of a dynamic theory. The object of the study was the interaction between policies and environment related human behaviour. The management of solid waste was the concrete setting for studying these issues. The process of theory development was guided by the System Dynamics (SD) methodology (Schwanninger and Hamann, 2005). An initial understanding of the system in question was developed applying the Group Model Building (GMB) methodology (Vennix, 1996; Andersen and Richardson, 1997). It delineates the model building procedures involving both researchers and problem owners – people affected by and experts knowledgeable about the issues under study.

The vehicle for the policy analyses, which was developed, was a differential equation model for Solid Waste Management (SWM model). The quality of the model, and the policy analyses realised with the help of that model, were of crucial importance to reaching the objective of the project.

We expected to gain valuable insights from this research design, enabling the formulation of a dynamic theory about citizens' choice and public policy, in the context of environmental management.

13.3 Part I: Problem Structuring and Conceptualisation

In the following, we will describe the activities undertaken and the results obtained during the phases of the project. To begin, the researchers conceptualised a design for a guiding framework. In parallel, and throughout Part I, a literature review and three Group Model Building (GMB) workshops were undertaken. These events brought together researchers, experts in environmental management, and the client group, i.e. a set of 'local system experts' who were knowledgeable representatives of the system under study. They were familiar with the system, and therefore in a position to judge the utility of whatever was developed in the project. Workshop participants were chosen according to two criteria. The first was a willingness to participate and cooperate in transdisciplinary research dealing with issues of sustainable development at the local level. The second was experience with projects aimed at promoting sustainable development. The workshops were facilitated by one of the authors (S. U.) and technical supporters. The objective of the workshop was the elaboration of a conceptual framework which would orientate further research. The main inputs to that event were the results of a higher level project of the SPPE, the Integrated Project 'Strategies and Instruments' (Full title: 'Strategies and instruments for sustainable development: Bases and evaluation of applications, with special regard to the municipality level with nine subprojects' SNSF no. 5001-48826).

The main outcome of these efforts was a 'Policy Framework for Solid Waste Management' (Fig. 13.1). It focuses on the determinants of environmentally

Fig. 13.1 Policy framework for solid waste management (Ull-Beer, 2004, 79)

responsible behaviour: the interaction between contextual constraints and opportunities on the one hand and personal, motivational and cognitive factors on the other (Kaufmann-Hayoz, 2006). This framework reflects the main assumptions underlying the ensuing work of model building and use in Part II.

According to this framework, policy makers can alter either the internal or the external structure in order to induce changes in behaviour (Kaufmann-Hayoz et al., 2001). Different types of policies, such as economic interventions, service and infrastructural measures, as well as budget constraints, can alter the external structure. On the other hand, communication policies and collaborative agreements can modify the individual factors. A more comprehensive description of this framework is given by Kaufmann-Hayoz (2006).

13.4 Part II: Developing a Dynamic Theory

Part II involved developing a dynamic theory. It made use of a specific case study, the subject of analysis being the management of solid waste in a Swiss community. The interaction between policies and environment related human behaviour was to be examined. The core of the process of theory building was the construction of a System Dynamics model and its use for policy analysis.

This part of the project was designed along the lines of four phases: Model – Test – Design – Change, and the respective steps. These phases and steps correspond to Integrative System Methodology (ISM), a heuristic methodology developed for management in complex settings (Schwaminger, 1997). The researchers made use of ISM as a methodology in their project because it allows the combination of different methodologies and focuses on dealing with complexity. In Table 13.1 the four phases are translated into the language of the System Dynamics (SD) methodology (Richardson and Pugh, 1981; Sterman, 2000).

Table 13.1 Phases and steps of Part II

Phases	Tasks/steps	Corresponding activities in the SD modelling process
Model	Ascertaining relevant perspectives, the goals and factors critical for attaining them	Problem recognition
	Surfacing issues	System conceptualisation
	Elaborating models	Building model
Test	Apprehending the dynamics of the system	Exploration and evaluation of model behaviour
	Simulating and exploring scenarios	
	Interpreting and evaluating simulation outcomes	
Design	Ascertaining control levers	Policy analysis
	Designing strategies/action programmes	
Change	Realising strategies	Model use

The municipality chosen for the action research was Ittigen. This is a community located in the agglomeration of Berne (Switzerland). It has about 11,000 inhabitants and is recognised for taking an innovative approach to its environmental policies. For example, Ittigen participated in the *light electro mobiles* (LEM) pilot and demonstration programme and in the Global Action Plan (GAP), an international environmental initiative. It also was the first municipality in Switzerland to implement the environmental norm ISO 14001. The authorities of Ittigen were willing to gain a deeper understanding of factors that determine the environmentally relevant behaviour of their citizens. They provided abundant information about their municipality for the investigation. The authors greatly appreciate the commitment and the support of the authorities of Ittigen in this research project.

13.4.1 Model

As reported above, the modelling phase started with a literature review on environmentally relevant behaviour, and environmental policy. In addition, one of the two 'gatekeepers' of the client group, the environmental manager of Ittigen (the other gatekeeper was the mayor of Ittigen), helped to determine the relevant actors that should participate in the model building process. Gatekeepers came from the client organisation and were responsible for the project. They acted as 'liaison' between the model builders and other people involved in the project. An important role of the gatekeepers was to motivate people in the client organisation, enhancing their commitment and participation (Vennix, 1996; Andersen and Richardson, 1997).

Three Group Model Building sessions were held in order to map the causal chains and feedback loops of interest, as observed in the municipality. At that point the modelling was of a qualitative type, i.e. no quantification took place yet. This kind of modelling is often called 'Qualitative System Dynamics'.

Ten experts, representatives of the local government, the local administration and consulting firms responsible for local management and policies in the realms of energy, transport, water/waste water, solid waste and consumption were involved. They shared their mental models about problems of environmental policy making to elicit patterns of policy resistance and compliance. The objective was to explain and reach consensus about causes and consequences of environmentally harmful behaviour of citizens, as well as the factors conducive to favourable behaviour. Although the interactions and processes still remained unclear it became obvious that policy intervention would influence different variables and subsequently change the various preconditions.

It was at that point that the 'Policy Framework' (Fig. 13.1) developed in Part I, showed its value in guiding the model building process. The driving forces specified in the framework (e.g. relative prices, number of recycling streams) could now be linked with the phenomena observed in the system (e.g. change in the amount of waste, purity of recyclable material).

To sum up, the framework enhanced the efficiency of the model construction and facilitated theory building. It was also crucial to the policy design phase, helping to widen the problem focus to the extent that preconditions for action choices were systematically considered.

Early on in the modelling phase, discussions were held with the authorities responsible for local solid waste management. The focus was on specific aspects of solid waste management. These discussions helped identify and clarify the main issues concerning solid waste management in the community, as seen by the authorities. Subsequently, the objectives of the modelling study were further refined. Hence in the system inquiry, both kinds of environmentally significant behaviour could be addressed: waste separation behaviour of citizens, i.e. behaviour that directly causes environmental changes; and solid waste management policies that shape the context in which citizens' waste separation behaviour takes place; and their interaction. Reference modes of the crucial variables of the local solid waste management system were mapped. A reference mode is a set of graphs and descriptive data that shows the development of the issue or problem under study, over time (Sternan, 2000). Figure 13.2 gives an example of such a reference mode showing both the past development path and a hypothesis about future developments – of the fraction of waste separated for recycling and the number of streams of the different recycled materials. As shown, a continued stepwise increase of the number of recycling streams, could lead to an inefficient logistic (excess capacity), a pattern known as overshoot behaviour.

Fig. 13.2 Hypothesised development of fraction separated for recycling and number of recycling streams (Ulli-Beer, 2004, 91)

13.5 Problem Description and Dynamic Hypothesis

Since citizens in the case community were failing to separate various streams of solid waste for recycling, the local authorities gave price incentives in the form of a garbage bag charge (implemented in 1991). The intended effect was to promote the desired separation behaviour. As a consequence the fraction of separated waste increased and the relative amount of solid waste for burning (variable 'fraction to be burned') decreased. The unintended effect was that not only the relative amount of waste disposed for burning decreased, but also the revenue generated from the garbage bag charges ('revenue from burnable material') declined. Therefore, the municipal budget deficit started to grow (via declining 'profit from solid waste management'). A further increase in the price for burnable material had almost no effect

Fig. 13.3 Dynamic hypothesis for local solid waste management (Ulli-Beer, 2004, 88)

The illustration of this dynamic hypothesis in Fig. 13.3 makes the features of feedback, delays, closed loops and multiple causes visible.

The next step specified the concrete concept of the model, including its boundary. Thereupon, one of the authors (S.U.) developed the quantitative SWM model with the support of experienced modellers. The model building process started with a simple first order 'concept model', which was a crude representation of the dynamic hypothesis (Richardson, 2006). The modelling process was not linear but rather a winding search for the right focus and approach – culminating in a promising structural representation of the system, which properly described the observed phenomena. From that point on, the model development process was guided by the dynamic hypothesis and the sector diagram of the solid waste management system. The model was made up of the following sectors: household waste separation, household decision making and local solid waste management. Sector by sector, the modules of the SD model were formulated and iteratively tested (Ullrich-Beer, 2003). For the quantitative modelling process the Vensim software was used. Vensim is a software program and a registered trademark of Ventana System, Inc. Co., Harvard, Massachusetts.

13.5.5.1 Test

In order to ensure the quality, strength and utility of the model for reliable policy analysis, the validation procedures adopted were a crucial aspect of the testing

Validity, in this context, is the level of confidence one can have in a model. The quest for proper validation resulted in a number of steps (Forrester and Senge, 1980; Barlas, 1996; Sterman, 2000). These take into account direct structural tests (reviews of model structure), indirect structural tests (computer-based tests of model structure) and behavioural tests (in the sense of behaviour replication, i.e. the fit of data resulting from the simulation model and the empirical data from the real system). The boundaries of this chapter would be overstretched, if all of these validation tests were described. We shall limit ourselves to an overview.

The broad theoretical background and the intensive exchange with experts who understood the system helped to build a dynamic theory about the mechanics of the solid waste management systems. Specifically, it helped to build the hypotheses about causal relationships that are captured in the model. Besides knowledge about the real system, theoretical frameworks also guided the modelling process, resulting in a model structure that was grounded in the relevant knowledge of the system. As model building progressed, each new structural module was evaluated with respect to the plausibility of its behaviour (reality check): Does it produce the right behaviour for the right reasons? Is it consistent?, etc. The model building and testing processes were helped by the reference modes as patterns of model behaviour could be checked in relation to these modes, during the different phases of model construction. By applying the behaviour reproduction test, flaws in the structure and mathematical functions were discovered and corrected. The final model showed a good fit with the reference modes. Testing the model was an iterative process by which an increase in confidence in the model was achieved in a stepwise manner. Once the basic model structure had been elaborated, different test procedures were conducted in order to fully understand the dynamics of the system and to test its robustness, consistency and correspondence with real data. In the middle of this phase an expert validation was held, in the form of a further meeting with the core audience – the knowledgeable representatives of the system. Their feedback was quite encouraging since the model structure, its assumption, its dynamics and the derived insights seemed plausible to them.

This group pleaded that the audience for the next meeting be expanded to include representatives from other municipalities as well as state and national agents. Like quality management, validation is a never ending process. Therefore, such an expansion would be a beneficial exercise in the next round.

13.5.2 Design

In this phase, two distinct classes of policy questions were addressed (Zagonel et al., 2004). Firstly, policy analysis experiments addressing 'What If' questions were conducted. A typical question was 'What might happen if we were to make such and such policy change?' With the model as a virtual laboratory, policy experiments were set up that looked back at previous policy initiatives (backcasting)

or forward to untitled future policies (forecasting). Secondly, scenario analysis experiments were set up addressing questions such as 'What might happen if some parameters or variables not under our control were to change dramatically?' The behaviour patterns resulting from the different policy experiments, using similar and different scenarios, were compared and explained. Furthermore, sensitivity analysis was used to explore the effects of uncertainty in the system. Figure 13.4 shows a simplified version of the model structure. The diagram is in the original SD notation with stocks (symbolised by boxes) and flows, which change the stocks (denoted by the valves). The picture represents a core aspect of the model – the diffusion process by which people become willing to separate their garbage into different streams of waste. The policy intervention points for influencing ('steering') the diffusion process are depicted by hexagons.

Detailed results of the different policy and scenario analysis experiments can be found in Ulli-Beer (2004, 2006) and Ulli-Beer et al. (2007).

During the policy design phase we reverted to a 'Practical Guide for Facilitating Environmental Policy Compliance', which was one of the by-products of the framework building phase (Ulli-Beer, 2006). This was essentially a checklist of possible measures for facilitating environmentally sound action, which helped us to enrich the policies indicated on the grounds of the quantitative computer simulations. All in

Fig. 13.4 Condensed diffusion model of people becoming willing to separate and intervention points for steering the diffusion process (adapted from Ulli-Beer, 2004, 120)

all, the policy programmes were designed so that not only the obvious problems were addressed. Rather, the approach aimed at strengthening the preconditions for desirable environment related behaviour of citizens and to overcome policy resistance in the system, i.e. increase policy compliance.

13.5.3 Change

In line with action science, this project has been executed together with two groups of collaborators. Firstly, those interest groups that would be most affected if there was a change in the environmental policies applied in the community under study. Secondly, the involvement of those decision makers who would be most effective in changing structures and rules in order to improve the situation. The task of the system inquiry was to understand how real world behaviour emerges out of real world structure. Understanding the crucial processes that explain undesirable patterns are important preconditions for influencing actors' motivation and knowledge and for implementing the most promising policy measures. Hence, the commitment of these collaborators was crucial for the acceptance of the policy recommendations and ultimately for the success of the project.

However, it had not been planned that the project include the implementation of the policy measures being developed. So where is the change?

The intended immediate change was not directly observable, i.e. a change of the collaborators' mental models due to a better understanding of the problem structure.

Furthermore, the logic of the System Dynamics methodology suggests a paradigmatic change. As the modelling and design progresses, the mindsets of the participants will change. At some point, instead of thinking in terms of simple cause and effect schemes, they will change to a more sophisticated rationale – thinking in feedback loops. They will assimilate a new understanding of the environmental issues, learn to look at the system from a feedback perspective, focusing on closed loops, delays and multiple causalities. This is seen as an important step towards a new management approach aimed at enforcing desirable developmental trends and avoiding undesirable ones.

Although this paradigmatic change is hard to substantiate we could observe some delayed change in the community indicating the probability that the mental model of the collaborators evolved. The mayor of Ittigen reported that an educational programme about municipal solid waste and recycling management was started at the local primary schools. Although we do not know definitely if this initiative is a direct consequence of our study, it directly reflects one of the main findings of the project: economic instruments are not sufficient to yield an efficient and robust policy outcome; further educational and service interventions are indicated.

However, in order to enhance the transformation of knowledge into action in other communities, further modelling workshops could have been rolled out. That way, the usefulness and adequacy of the developed model and theory could be further tested and extended. The action science approach would call for such a continuation.

13.6 Recommendations

The objective of this article was to draw lessons for transdisciplinary modelling endeavors in social contexts, based on an in-depth study of a complex process of inquiry. The case was profoundly characterised by an involvement of 'problem owners' and other stakeholders into the research process.

The described approach resulted in a dynamic theory that explains observed behaviour patterns of a local solid waste management system and provides policy recommendations for its improvement. Model interfaces and policy experiments can also be used, in the future, as a scientifically grounded decision support system that informs the debate on policy design in solid waste management.

Having reviewed the phases of the whole project, a puzzling phenomenon emerges, which can be coded in one polarity, the polarity between plurality and unity. It leads to questions of the following kind:

- 'How could a coherent body of knowledge come about under these circumstances?'
- 'How could inputs from different stakeholders with distinct disciplinary backgrounds and interests result in a consistent model?'
- 'How could a process of change in a dynamic social context be induced?'

The key to these questions is transdisciplinarity. The different views of all the people involved were integrated and condensed using the SD model. Such a model is essentially a language based on system theory. It allows for variables originating from different domains, e.g. economic, social, ecological and technological, to be connected to form a consistent picture. The system theory language was the key to transdisciplinarity. Initially, it was owned by the facilitators. As the dialogue between the different constituencies of the project evolved, the systemic thinking and the command of the new language spread among participants, enabling genuinely transdisciplinary conversations. To conclude, without such a transdisciplinary approach, it would not have been possible to develop a model such as the one outlined here or induce a policy learning process.

We would like to conclude with a set of recommendations for researchers who want to explore and investigate multifaceted, dynamically complex issues together with stakeholders. We underline that this is pragmatic advice rather than scientific teaching. Here are seven points, which appear to be very important.

According to these assumptions, the flow of human action is regarded as part of the continuous interaction – through the processes of perception of action – between the internal structure of the actor (personal factors and processes) and the external structure (contextual factors and processes with cultural, socio-economic, institutional, and physical aspects). The external factors offer options but they also constrain human behaviour. They are the result of a multistage decision making process in the political/administrative, technological and economic domains. As far as they are perceived by actors, they influence actors' actions, but actors can also change the external structures through their actions.

Design the project for a transdisciplinary inquiry. The traditional disciplinary and even multidisciplinary approaches are in principle insufficient for adequately dealing with complex issues. Therefore, a transdisciplinary setting for the inquiry must be created. The interaction between the holders of different kinds of expertise must be facilitated, and it should rely on a common, integrative language.

Use frameworks to manage the relevant body of knowledge. Identifying relevant knowledge, e.g. helpful disciplinary concepts, is an iterative research process. In this process, scientifically grounded frameworks can serve as heuristic devices of great importance. They help to integrate different disciplinary perspectives and to organise blocks of insights, as well as to structure the issue in a transdisciplinary mode. Most notably, they are apt to trigger a systematic process of modelling and learning.

Apply a unifying perspective when structuring the issues under study. The systems view is a powerful conceptual approach to complex projects such as the one reported here. In this case, it proved most helpful in determining the field of investigation and then in integrating the different perspectives. It was also crucial for the exploration of relationships between the different system components, i.e. the essential factors that had to be represented in the model. For example, the 'Policy Framework for Solid Waste Management', is an essentially systemic model. It visualises the basic controlling loop between actors and their context. Equally, the SD methodology of modelling and simulation embodies a systems theory, which enables unifying distinct perspectives in one and the same model.

Choose a proper methodology for dealing with dynamically complex issues. A diagnosis, a system design and its implementation can only be as good as the underlying methodology. The Integrative Systems Methodology applied in this case offers a reference methodology that allows for combining complementary research approaches with a focus on dealing with complexity. Group Model Building and the qualitative System Dynamics approach proved to be useful for the development of an insightful dynamic theory on recycling dynamics. The quantitative model building process helped identify and integrate useful disciplinary concepts and findings so that the dynamic theory could be consolidated and a useful decision support tool could be developed. Another significant result was that microprocesses that explain macrobehaviour could be modelled and analysed.

Customise the policy mix. A model, such as the one developed here gives evidence that the interaction and impact of different policies are situation-dependent, i.e. they vary with the contextual and personal factors of the concrete behavioural setting. When sensitive policy parameters of the system are identified, knowledge of the mode of functioning of different policy instruments is extremely important so that the most effective policy package will be chosen. Adequate policy making tools such as a System Dynamics model can allow the policy mix to be customised close to an optimum.

Master the crux of policy implementation and policy resistance. The representation of both internal (personal) variables and external contextual variables in the decision rules of the model provides a broader basis for policy analysis. For local authorities, it opens up richer options for intervention and implementation. This is

fundamental for coping with complexity, in the sense of Ashby's Law of Requisite Variety (Ashby, 1956). Furthermore, focusing on the interplay between contextual and personal influences is crucial in order to understand the phenomenon of policy resistance. In addition, it points out important system requirements vital to achieving high policy compliance. There may be a lot of 'sand' in the 'mechanism'; however, in order to be effective, it is important to understand the dominant processes guiding policy compliance.

Effective system change requires a participative research design. One must add that the set of participants in the process of inquiry should include different stakeholders, and that these should be included throughout all research phases. The colloquial term 'audience' is often used for the participants who are not researchers or moderators. Figure 13.5 suggests one template of a research design that systematically includes practitioners in the inquiry process. It is built on the ISM and SD modelling phases and is inspired by Beer's methodology of topological maps and scientific modelling (Beer, 1984). Also, the modelling steps and Group Model Building scripts offer crucial stimuli for improved learning in complex decision making situations. Finally, the perceptions of participants should be monitored carefully so that the interventions can be improved and collective learning be achieved.

Fig. 13.5 Template of a transdisciplinary approach to modelling and policy learning (Ulli-Beer et al., 2006b)

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